

Advanced Instrumentation Bolsters Lethality Testing

State-of-the-art live fire testing resources are keys for evaluating evolving military weapons systems

by Tracy V. Sheppard

Live fire testing of weapons systems is mandated by law. More importantly, it is necessary because it is a cost-effective, comprehensive way to evaluate military systems. When operating as designed, these systems save lives and win battles. The objective of live fire testing is to support a timely and thorough assessment of the vulnerability/lethality of a system as it progresses through its development and subsequent production phases.

As a major range and test facility base, Combat Systems Test Activity at Aberdeen Proving Ground, Maryland, brings together state-of-the-art test and engineering equipment, scientists, and technicians to provide military hardware.

Title 10, United States Code, mandates that major weapon systems and munitions programs undergo a realistic live fire test and evaluation. Live fire testing involves ultra high-speed photography, flash radiography, toxic gases, second-degree burns, shock and vibration, incapacitation levels, injury curves, firepower, mobility, communication kills, and even the dreaded K-kill—the catastrophic loss of a system.

Proving Survivability

The activity demonstrates the ability of a system under test to provide battle resilient survivability and lethality. It gives insights into the principal damage mechanisms and failure modes occurring as a result of the munitions/target interaction. Live fire testing also produces techniques for reducing personnel casualties. In other words, the live fire tester puts a system through a test which, as closely as possible, duplicates an actual combat environment.

In survivability testing of a troop-carrying vehicle—from tanks to howitzers, to high mobility multiwheeled vehicles—this means setting the vehicle up just as it would appear in an actual combat environment, with full compliment of munitions, vehicle and crew stowage, crew simulants and fuel. In lethality testing this means engaging a real-life target and assessing the ability of the munitions to defeat that target.

Acquiring the data for live fire test and evaluation requires intensive knowledge and experience. To meet the specialized demands and congressional oversight, specialized testing sites are critical. At Aberdeen Proving Ground, three test ranges in particular meet this demand. Test Range AA-5 accommodates both survivability and lethality testing. It is a stand-alone test site, and represents a state-of-the-art test facility.

Survivability testing puts a target system in an environment where it can be attacked from ranges up to 1,000 meters. Threat munitions can also be statically detonated at three different sites within the AA5 area. To simulate air-launched threats, a computer-controlled, elevating ballistic rail is used. The elevated rail permits missile angle-of-attacks of between 0 and 88 degrees.

Acquiring electronic data in an environment where large items are being subjected to destructive, highly volatile tests is a difficult task. Extensive measures were incorporated into AA-5 at the earliest stages of construction to ensure a high degree of data quality. For example, power for environmental equipment such as theaters, air-conditioners, or pumps, is isolated from the conditioned power sources for the instrumentation-ballistics, toxic gas, thermal radiation, video and high speed film, radar, and X-ray.

Also, data transmission lines are heavily shielded from electrical interference as well as from fragmentation. This facility has been the home of many of the congressionally mandated tests and has seen many distinguished visitors, including former Defense Secretary Frank Carlucci.

Superbox

As armor and threat rounds progressed to the use of heavy materials such as depleted uranium, the need arose for a facility to accommodate environmental and personal safety concerns. The desire to have the capability to test full-scale, fully loaded combat vehicles within the structure compounded the problem.

To facilitate this testing, the activity developed Superbox. Superbox is the depleted

uranium containment facility. It permits full-scale, full-up testing of complete, major weapon systems. The containment vessel is 84 feet in diameter and is capable of withstanding an internal detonation of up to 100 pounds of TNT equivalent or a burn of 650 pounds of propellant.

Protruding from the vessel is a 60 foot long by 16 foot diameter flight tunnel. At the entrance to the flight tunnel is the "world's fastest door," as reported in Popular Mechanics magazine. After the threat round has passed the tunnel opening, explosive devices detonate, slamming the door closed within 40 milliseconds, thereby protecting the environmental integrity of the containment vessel.

The filtration system is a four train air system—two supply and two exhaust. Twenty air exchanges take place within an hour. The facility houses a lift station, a collection tank for liquid wastes, a clarifier that removes suspended solid material, an oil/water separator, and a recovery tank.

Underwater Explosion Test Pond

Increasingly strict environmental regulations have also impacted testing conducted by the U.S. Navy. Moved from the oceans, to the Gulf of Mexico, to the Chesapeake Bay, to Bush River, Maryland, the Navy's testing was headed downstream until Combat Systems Testing Activity, in conjunction with the Navy, developed and constructed the underwater explosion test pond.

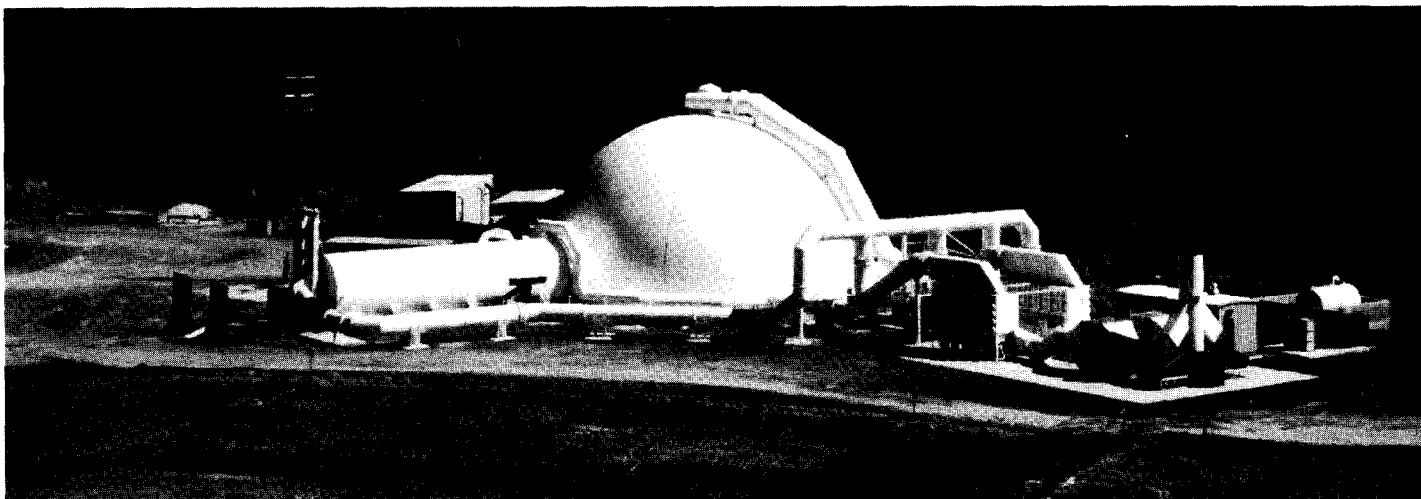
The pond measures 330 feet in surface diameter, is 60 foot deep, and has a flat bottom diameter of 70 feet. It can be used for surface and subsurface shock testing and has a maximum explosive charge weight capability of 400 pounds TNT equivalent. To complete the Navy's in-shore testing requirements, Combat Systems Testing Activity is currently constructing the underwater test facility. It will be 1,000 feet in surface diameter, 150 foot deep, and will have a flat bottom diameter of 300 feet.

The maximum explosive charge weight will be 4,100 pounds TNT equivalent. The facility also boasts a barge slip for delivery of test items directly from the Chesapeake Bay.

These three facilities have one common factor—their instrumentation. The test activity has incorporated into these facilities the most advanced data acquisition and engineering equipment available, which can be divided into the following categories—photographic and radiographic; toxic gas; thermal radiation; ballistics; automotive; and asset protection.

Photographic and Radiographic

Both 35mm and 120mm still photography, as well as video, are used to document each step of the live fire test process. The process begins when the test assets arrive and is not



completed until the last test event is conducted. The pictures and video provide an accurate, descriptive account of the entire test cycle.

Remotely operated pan-and-tilt video cameras are also used to provide test documentation and a remote viewing capability at a safe distance from the test. High speed film, typically between 5,000 and 10,000 frames per second, is used to document threat orientation during flight-to-target and at target impact.

Opposing cameras are used to document yaw and pitch deviants as well as impact orientation of the threat. Doppler radar systems are frequently used to acquire muzzle, in-flight, and striking velocities. High speed, high voltage, flash radiography equipment is also a proven asset when test requirements dictate a need for permanent, clear images of extremely high speed events. Radiographic instruments emanate high fluence densities over brief time periods to capture silhouettes of metallic objects without blurring or streaking.

Measuring Toxic Gases

Toxic gas concentrations within the confines of a troop-carrying vehicle are extremely important as toxic gases can be both incapacitating and deadly and can be undetectable to the crewman. Of particular interest are the concentrations of carbon monoxide, carbon dioxide, nitric oxide, nitrogen dioxide, hydrogen fluoride, hydrogen bromide, hydrogen chloride, acrolein, formaldehyde, and hydrogen cyanide.

All of these compounds may be formed in the event of a perforation into the troop compartment of a vehicle or in the event of an on-board fire. Toxic gases are typically measured at each crew position within the troop compartment before, during, and after a test event. A complete history of toxic gas concentrations within the confines of the vehicle is produced. Once concentration levels have been determined, the values are compared

against criteria developed by the surgeon general's office to derive crew incapacitation levels.

Measuring Thermal Radiation

During typical live fire testing, free air thermocouples and heat flux calorimeters are placed on the crew simulants; normally three thermocouples and two calorimeters per simulant at a minimum. Heat flux measurements allow the summation of radiant, conductive, and convective thermal loads. Prediction of second degree burns is accomplished by comparing the acquired thermal readings against established burn criteria.

Crew acceleration data is acquired through the use of human-hybrid simulants. These hybrids are identical to those in use throughout the automotive industry in crash testing. They provide acceleration data in three axis at three general locations-head, chest, and pelvis. Additionally, some advanced hybrids provide shear, bending, compression, and torsion measurements at the neck, the spine, and in the legs.

Crew blast overpressure data is acquired through the use of pressure transducers which are typically affixed to the crew simulants. Overpressure data is analyzed against a human injury curve to determine a level of incapacitation as a result of exposure to pressure waves of varying magnitude and duration. Component ballistic shock data and material strain data are acquired through the use of piezo-electric and piezo-resistive accelerometers and through the use of strain gauges.

Accelerometers and strain gauges are affixed to critical components and/or rigid armor to determine shock loads transmitted to the vehicle as a result of an attack. Shock data is compared against an established criteria for the particular system being tested to determine damage or degradation to a given component or structure. One readily apparent outcome of this data is the use of shock damping material in component mounting procedures.

The \$13.5 million depleted uranium containment facility at Aberdeen Proving Ground, Maryland, permits full-scale testing of complete, major weapon systems.

Automotive Instrumentation

Live fire testing and evaluation could not be complete without a detailed, accurate account of the target vehicle's response to the attack. In the initial phases of the test, a baseline of vehicle performance is established against which all post-shot automotive tests are compared. The baseline test includes such parameters as top speed, acceleration, and braking distance.

Also, on-board electronics such as range finders, optical sights, ballistic computers, and communications equipment are thoroughly tested for the baseline. Following each test event the vehicle is retested in a like manner to determine if any degradation of the vehicle's components has occurred.

The final instrumentation group is that package of equipment which protects the target asset. Live fire testing and evaluation typically involves destructive testing against multimillion dollar vehicles or other equipment. And although the tests are destructive in nature, it is not the intent of the testing process to destroy the assets. The asset protection system employs omni-directional, pan-and-tilt fire nozzles, which permit direct and accurate application of water and/or aqueous foam onto the asset.

In addition to this external protection, Halon, CO₂, and water lines are plumbed into the vehicle's crew area and engine. Live fire testing demands the most advanced electronic and mechanical instrumentation. When a typical live fire event may cost upwards of \$75,000, data acquisition becomes extremely important. **ND**

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